TESTS OF PENETRATING SPRAYS TO CONTROL BARK BEETLES 1951[1/]

INTRODUCTION

A constant objective of forest entomologists has been to develop cheaper and more effective means of killing destructive forest insects. Early methods of controlling bark beetle broods required the felling, trimming, and cutting off of the infested length of the tree followed by removal of the bark, exposing the developing broods to control agencies. While effective, these methods were laborious and expensive. An improvement was the decking and burning of infested logs. Although cheaper, damage of nearby trees and danger from fire were objectionable features. Burning infested trees standing still further reduced costs but had the same undesirable features.

Chemicals introduced into the conducting tissue of trees gave good control of bark beetle broods under favorable conditions, but the latter were too limiting for use on many control projects and the method was not recommended.

Killing bark beetle broods by using Diesel oil as a carrier of a lethal material through the bark of logs to infesting broods beneath, was adopted as the next improvement. Since then, and where conditions permit, trees with short infested lengths have been sprayed standing, still further reducing the control cost per tree. However, transport of large quantities of Diesel oil and lethal agent to remote and relatively inaccessible control jobs has proved decidedly costly. A forest entomologists' hope has been to develop some powerful killing agent for bark beetles which, in concentrated form, could be added to a tank of water, sprayed on logs or trees, and kill the bark beetle broods but not the beneficial insects. That ideal seems a long way from being realized but development of an emulsion of ethylene dibromide in water is a step in that direction. Local supplies of water can thus be used, permitting a reduction in material to be transported of from 67 to 80 percent.

Tests with this emulsion and of ethylene dibromide in Diesel oil were conducted in 1951.

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Tests of an Ethylene Dibromide Emulsion to Control the Mountain Pine Beetle in Lodgepole Pine 1951

In the spring and early summer of 1951 tests were conducted on the Lynch Lake control area in Montana. On May 21 and 22 twelve felled, and an equal number of standing, mountain-pine-beetle-infested lodgepole pine were treated with the aforementioned emulsion, composition of which was as follows:

Composition of Emulsion Tested Against Broods of Mountain Pine Beetle in Lodgepole Pine

Ethylene dibromide	2 lbs.
Triton X-100	3 oz.
Triton B-1956	5 oz.
Diesel oil to above to make	1 gal.
Add water	4 gal.

This emulsion was applied until the bark surface glistened with accumulated liquid and runoff was imminent. A back-pack hand pressure pump of about 3½ gallons capacity was used for spraying. On felled trees, five-foot treated sections were alternated with equal-length untreated sections to height of brood on the bole. By so doing both check and treated sections were placed on a comparable basis for measuring results of treating. Standing trees were sprayed to a height of 9.5 to 11 feet, six on all sides and the rest on one-half of the circumference, the untreated portion to be used as a check area. It was found in treating log sections of felled trees that one gallon of spray covered about 40 square feet of bark surface. On standing trees only 29 square feet were covered per gallon of emulsion. Loss of spray from spattering as it hits the trunk of a standing tree, is believed to be largely responsible for the greater amount needed to obtain the same visual degree of surface saturation on a standing tree as on a log. In these tests, conducted on May 21 and 22, control was directed against broods which had reached the mature larval stage of development and averaged about 69 per square foot of bark surface.

One month after treating only one normally active and 19 dying larvae were found in treated log sections under 73 of the 344 square feet of bark surface sprayed. Under 53.5 of the total of 254 square feet of bark surface from trees treated standing, only five normally active larvae were found. An estimate of control effectiveness, even considering apparently dying larvae as survivors, would average 99.7 per cent for the two series of tests. Some of each of the felled and standing trees had deeply ridged bark up to two inches thick extending for a short distance up from the base. Such excellent control under this unusually thick bark, indicates a high degree of effectiveness for the emulsion. More detailed data is given in Table 1. Inspection of brood in untreated sections and trees, revealed only light normal mortality.

Table 1. Mortality obtained from spraying mountain-pine-beetle-infested lodgepole pine with ethylene dibromide emulsion. Lynch Lake, Montana - 1951.

Number of Trees Treated	Sq. Ft. of Bark Treated	Sq. Ft. of Bark Examined	Brood Status - Treated Area Dead Number	Dead %	Living Number	Living %	Comments
			Data from log sections				
7	233.6	47.0	3,243	100	None	None	
5	110.4	26.0	1,774	98.9	20	1.1	All but one survivor under abnormally thick bark.
12	344.0	73.0	5,017	99.6	20	.4	
			Data from trees treated standing				
11	229.5	49.5	3,415	100	None	None	
1	24.5	4.0	271	98.2	5	1.8	No apparent reason for five surviving larvae.
12	254.0	53.5	3,686	99.8	5	.2	

1/ Estimated after sampling counts to establish average.

To be certain of emulsion effectiveness against other stages of mountain pine beetle development, seven standing trees were sprayed on July 3, 1951 to a height of about eight feet. Control was sought of broods which had reached chiefly the pupa and new adult stages. Coverage of bark was about 33 square feet per gallon of spray. On July 9, just six days later, an examination of five of these trees revealed that over 94 percent mortality had occurred in that brief interval. A second examination on July 19 and 20 produced only one surviving larva under 24.9 square feet of treated bark surface removed from the seven trees with dead pupae and new adults numbering an estimated 1,580 or 74.1 per square foot. Control obtained can be considered as 100 percent. Living brood under 7.3 square feet of untreated bark surface, removed at 9 to 10 feet above ground, revealed there had been a normal mortality of about 6 percent. Dead and living larvae, pupae, and new adults were about 69.6 per square foot at that height on the trees. Data for treated and untreated areas is shown in Table 2.

Table 2. Mortality of broods of mountain pine beetle in lodgepole pine resulting from treating with ethylene dibromide emulsion - 1951 Lynch Lake, Montana.

Tree Number	Height of Examination on Tree of Bark Surface: Treated: Sq. Ft. Bark Examined	2 - 5 Ft. Brood: Dead	Living	Sq. Ft. Bark Examined	6 - 7 Ft. Brood: Dead	Living	Untreated: Sq. Ft. Bark Examined	9 Ft. Brood: Dead	Living
25	1.2	90	--	.8	144	--	.5	--	104
26	1.5	108	--	1.2	136	--	1.0	2	61
27	1.1	156	--	.8	92	--	.7	19	49
28	5.0	64	--		No broods			No broods	
29	2.0	251	--	2.1	69	1(1)	1.0	--	49
30	2.3	254	--	1.9	100	--	1.6	--	28
31	2.3	43	--	2.7	72	--	2.5	--	30
	15.4	966	--	9.5	613	1	7.3	21	321
Weighted Average per sq. ft.		79.5	--		65.7	.1		4.8	69.6

(1) Only survivor noted in treated area

Effectiveness of ethylene dibromide emulsion for fall control has yet to be determined. Rapidity of control obtained in early July with this formula indicates the possibility of equal effectiveness with smaller amounts of lethal agent, emulsifier, and surface active agents per gallon of spray. As these ingredients are expensive, material savings may be possible with lighter concentrations of them.

Tests with Ethylene Dibromide to Control the Mountain Pine Beetle in Western White Pine - Coeur d'Alene N.F. 1951

Tests with ethylene dibromide as lethal agent were initiated in late spring of 1951, on Beetle Creek of the Wallace District of the Coeur d'-Alene National Forest. This chemical, in mixture with Diesel oil, seemed to offer little if any saving in cost of materials per gallon over present orthodichlorobenzene - Diesel oil spray costs. Possibility of an ethylene dibromide emulsion proving effective did, however, offer prospects of decided savings in transportation costs as discussed earlier in this report.

In using penetrating sprays, this laboratory has found that bark beetle broods in standing trees are more difficult to control than in logs. This difference may be due to the position of the material while being sprayed. When logs are treated, the upper side is sprayed, the log is then turned until an adjoining unsprayed portion is uppermost, that is sprayed and the turning and spraying repeated until the entire circumference of the log is treated. Spraying in this manner permits gravity to assist the spray in penetrating the bark. Standing trees do not have this action of gravity to aid in spray penetration and that is probably the reason control is more readily obtained in logs than in standing trees. As conditions did not permit testing both kinds of material, spraying was limited to standing trees except for a series of windfalls.

To be assured that tests would be representative, all stages of brood development, except eggs, were represented in the trees sprayed. Brood stages and number of trees or samples sprayed for each test are given in Table 3.

Table 3. Brood status of mountain-pine-beetle-infested western white pine treated with penetrating sprays - Beetle Creek, Coeur d'Alene National Forest, June, 1951.

Formula	Date Treated	Status of Treated Material	No. of Trees or Samples	Percent of Developmental Stage when Treated (1) Larvae	Pupae	New Adults
E.D.B. Emulsion (2)	6-8-51	St'd'g trees	8	91.5	6.9	1.6
E.D.B. Emulsion (2)	6-13-51	" "	8	27.1	25.5	47.4
E.D.B. in Diesel (3)	6-14-51	" "	6	55.7	40.4	3.9
E.D.B. Emulsion (2)	6-15-51	Windfalls	10	83.2	14.8	2.0

(1) Average figures for all samples in test. Variation between samples in brood development sufficient to adequately represent all stages.

(2) Ethylene dibromide 2 lbs.
Triton X-100 3 ozs.
Triton B-1956 5 ozs.
Diesel oil to above
to make 1 gal.
Water 4 gal.

(3) Ethylene dibromide 1.5 lbs.
Diesel oil to above
to make 5 gal.

The first test with the emulsion was made on June 8, on eight standing trees selected because infesting broods were chiefly in larval stages. These trees were treated to a height of 10-11 feet. Spray was applied until surface saturation was reached as indicated by glistening of the bark surface and beginning of runoff. Average coverage per gallon of spray was 32.9 square feet. On July 16 and 17 these trees were examined to determine spray effectiveness. The data are shown in the upper section of Table 4.

A second test was conducted on June 13 of seven standing trees containing broods more advanced in development than in those used for the preceding test. The same formula was used, the spray was applied in a similar manner, and visual degree of coverage was the same. On an average, a gallon of spray covered 35.6 square feet of bark surface. Data from examinations made on July 12, 13, and 17 are shown in the lower part of Table 4.

Six infested, standing, untreated trees were examined as checks on treatment effectiveness. On these trees no attempt was made to make detailed counts of dead and living broods as it was deemed sufficient to learn that there had been no abnormal mortality.

Table 4. Ethylene dibromide emulsion effectiveness against broods of mountain pine beetle in western white pine - Coeur d'Alene National Forest 1951.

No. of Trees	Sq. Ft. Bark Exam.	Status of Broods When Examined: Dead Larvae	Dead Pupae	Dead New Adults	Living Larvae	Living Pupae	Living New Adults
Test on broods of over 90 percent larvae							
7	14.2	542	44	11	--(1)	--	--
1	2.0	79	3	--	2	--	--
	16.2	621	47	11	2	--	--
Percent dead and living 99.7.						.3	
Test on broods of over 67 percent pupae and new adults							
6	18.5	150	144	340	--	--	--(2)
1	4.0	60	54	27	2	2	3
	22.5	210	198	367	2	2	3
Percent dead and living 99.1						.9	

(1) No apparent reason for survivors.

(2) Survival believed to be due to thick bark near base of tree where both bark and wood were moisture saturated.

Survivors observed at the time these trees were examined were so few in ratio to those killed that they can be ignored as far as overall effectiveness of the tested formula is concerned. Control of larvae as well as the more mature broods which were present in these trees, may be considered as practically complete.

The preceding two tests show that ethylene dibromide emulsion is equally effective on all stages of brood development of the mountain pine beetle in standing trees.

A spray mixture of ethylene dibromide and Diesel oil was tested on six standing trees, treating to a height of approximately eleven feet. Data obtained from these trees, examined about one month after treating, is given in Table 5.

Table 5. Effectiveness of an ethylene dibromide-Diesel oil spray against broods of the mountain pine beetle in standing western white pine - Coeur d'Alene National Forest, 1951.

Tree Number	Sq. Ft. Bark Exam.	Status of Broods when Examined: Dead Lar.	Dead Pup.	Dead N. A.	Living Lar.	Living Pup.	Living N. A.	Remarks
8	1.5	36	97	2	--	--	--	
12	2.5	69	50	--	--	--	1	No apparent reason for survival.
15	2.0	35	33	23	--	--	2	Survivors near base where bark was thick and wet.
20	2.0	35	--	--	--	--	--	
21	2.0	85	81	--	--	--	1	Survivor near base of tree where bark was thick and wet.
22	2.0	113	10	1	--	--	1	Survivor believed to have been in lightly sprayed spot.
Totals	12.0	373	271	26	--	--	5	
Grand Totals and percent dead and living.		670		99.3%	5	.7%		

Inspection of the preceding table reveals so few survivors that again they may be considered negligible in measuring the overall effectiveness of this oil-base formula.

It should be pointed out that less spray was used to obtain the same degree of coverage with the Diesel-oil-base spray than with the emulsion. It is possible that square feet of bark coverage per gallon of emulsion can be increased and still give effective control. If that can be done the emulsion would thus be on a par with the Diesel-oil-base spray, otherwise we must accept the need for at least a third more emulsion spray to equal the effectiveness of those having a Diesel-oil base.

At irregular intervals the annual normal loss of a few white pine by windthrow is supplemented by much heavier blowdowns over more or less extensive areas. These windfalls offer excellent host material for build-up of mountain pine beetle broods to a level which threatens prohibitive losses to adjoining timber. Costs of controlling infesting bark beetles, especially if the windfalls are scattered over comparatively inaccessible areas, are likely to be quite high. To be reasonably sure of acceptable control, trimming and cutting into logs so they may be turned as they are sprayed, has been considered necessary procedure. Treating windfalls "as is" (without trimming, bucking, and rolling) was planned in the hopes of reducing treating costs per tree. Five windfalls were so treated, a sixth was trimmed, cut into logs, and turned after applying the spray to the consecutively exposed upper side. Emulsion of ethylene dibromide was the spray tested.

All degrees of brood development, except eggs, were present in the material selected for treating. These windfalls had been attacked the previous year, 1950, some apparently in early summer, others late in that season. This spray was applied to the same degree as on standing trees, until bark surface saturation was evident. Compared with standing infested trees, these windfalls, in general, had wetter bark; in some cases a supersaturated condition was noted. By the time of examination two of these windfalls were found to have been "filled in" by other bark beetles. Larvae of the latter were so intermingled with and similar to those of the mountain pine beetle, as to cause too much difficulty in attempting to separate them. However, ample data was obtained from the four remaining windfalls on which to base conclusions. Data was obtained from the remaining three treated "as is", the fourth was turned as it was sprayed. Data from this test are given in Table 6 with that from three of the trees divided into a basal section "a" where the bark was thicker and usually more moist, and a higher section "b" extending above 15 feet from the base. Each entry is the total of two or more samplings in their respective sections.

Table 6. Ethylene dibromide emulsion effectiveness against mountain pine beetle broods in western white pine windfalls, Coeur d'Alene National Forest - 1951.

Tree Number	Sq. Ft. Bark Exam.	Status of Broods when Examined: Dead Lar.	Dead Pup.	Dead N. A.	Living Lar.	Living Pup.	Living N.A.	Remarks
24	12.0	35	1	--	11	--	--	Not turned as treated.
27a	4.0	119	4	5	--	--	3	"
b	5.0	79	9	--	7	--	12	"
28a	2.0	13	5	--	3	3	38	"
b	2.5	11	22	2	--	2	24	"
39a	1.5	46	15	1	--	--	--	Turned as treated.
b	1.5	23	2	--	--	--	3	"
Totals	28.5	326	58	8	21	5	80	
Grand total of dead and living		392 = 78.7%			106 = 21.3%			

Treated 6-15-51
Sections of bole treated

Examined 7-17-51
Spray used = 6 gallons
Sq. ft. bark covered per gal. of spray = 57.7

Percent of control obtained on windfalls treated "as is" was insufficient to recommend the emulsion for treating that type of material in that manner. Survivors were found on all but one of the many sections examined. Cause of survival was not apparent but it is quite possible the emulsion was unable to replace the abundant moisture in bark and cambium of many of these windfall sections, thus permitting survival of infesting broods. Over limited areas of bark in well-shaded places, bark surface on the underside of some windfalls was wet. This wet condition is also believed to be responsible for the large amount of bark surface covered per gallon of spray. Wet bark on the underside of windfalls seems unable to absorb a lethal amount of this spray. An exception to the unsatisfactory control was observed on windfall number 39, on which excellent control was noted. This windfall was turned as it was treated, the upper side being treated, then turned until an untreated portion was uppermost, that was treated, then turned as before and the process repeated until the entire circumference had been sprayed. Although the reason for excellent control under these conditions is obscure, it is possible that gravity, even though acting for but a short time on the various sides of the log, may permit replacement of some bark moisture with sufficient lethal emulsion to kill broods in the cambium layer. However, with much limited data available, no definite conclusion can be drawn.

SUMMARY

In discussing results of these tests the following assertions can be made:

(1) Ethylene dibromide emulsion is effective for spring control against mountain pine beetle broods in standing white pine. Past experience has shown that a spray effective against mountain pine beetle broods in standing trees also gives effective control of the same insect in logs from felled trees of the same tree species.

(2) Ethylene dibromide in Diesel oil is effective for spring control against broods of the mountain pine beetle in standing western white pine.

(3) Ethylene dibromide emulsion is only partially effective against broods of the mountain pine beetle in western white pine windfalls which are treated without turning. Although the exact reason for this is not definitely established, it is believed to be due to inability of the emulsion to displace moisture of supersaturated bark in sufficient quantities to control infesting broods in the cambium layer.

Suggested further tests.

Control was insufficient in windfalls sprayed "as is" but one tree which was turned as it was treated showed excellent, although not complete mortality. Success in this one instance may indicate it would be generally effective if all windfalls were similarly treated. Tests to determine the answer to this question should be conducted the coming season.

No tests have been made to determine if this formula would be effective for fall control. That question should also be answered this coming season by a series of tests.